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An Overview of the Mixed Waste Landfill Integrated Demonstration

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Introduction

The US Department of Energy established the Office of Technology Development (OTD) as an element of Environmental Restoration and Waste Management (EM). EM manages wastes generated from current operations and remediation of all DOE sites. OTD has a mission to rapidly develop, demonstrate, and transfer needed environmental technologies to Environmental Restoration, Waste Operations, and Defense Programs. As part of this initiative, OTD is supporting a network of Integrated Programs (IP) and Integrated Demonstrations (ID). Integrated Programs focus on technologies to solve specific aspects of environmental or waste management problem. Integrated Demonstrations "integrate" the "demonstration" of innovative technologies that are proposed by federal laboratories / universities / industry research partnerships. Each ID is focused upon a different environmental need aimed at resolving specific problems representative of generic DOE environmental issues.

The Mixed Waste Landfill Integrated Demonstration (MWLID) focuses on "in-situ" characterization, monitoring, remediation, and containment of landfills in arid environments that contain hazardous and mixed waste. The MWLID mission is to assess, demonstrate, and transfer technologies and systems that lead to faster, better, cheaper, and safer cleanup. The demonstrated technologies will be evaluated against conventional baseline technologies and systems. Comparisons of cost, efficiency, risk, and feasibility of using these innovative technologies at other sites are being conducted. The MWLID is working to transfer these technologies to the private sector for commercialization and routine use by environmental restoration groups for the cleanup of similarly contaminated landfills throughout the DOE complex.

The MWLID is demonstrating technologies at Sandia National Laboratories' Chemical Waste Landfill, Mixed Waste Landfill, Technical Area II Classified Waste Landfill, and an Air Force Weapons Laboratory Solid Waste Amendments (HSWA) site. The Chemical Waste Landfill received chemical hazardous waste from the Laboratories from 1962 to 1985, and the Mixed Waste Landfill received hazardous waste and radioactive wastes (mixed wastes) over a twenty-nine-year period (1959-1988) from various Sandia nuclear research programs. The Technical Area II Classified Waste Landfill contains VOCs, inorganic, and mixed waste, has recently been to added as a demonstration site. These landfills are now closed. The Kirtland Air Force Base Hazardous and Solid Waste Amendments (HSWA) site, operated from 1960 to 1973 by the Air Force Weapons Laboratory, received waste from radiobiological experiments. These sites were selected because they are representative of many sites throughout the southwest and other arid climates.

The MWLID program is divided into four areas: Characterization and Monitoring, Remediation, Containment, and Technology Integration.

Characterization and Monitoring

Site Characterization must include detailed information about the contamination including the source, types, mobility, and amounts as well as the spatial distribution of each contaminant. Quantitative information about the geologic and hydrologic properties of the site also must be determined so environmental scientists can accurately predict how contaminants behave underground. Multiple technologies are needed to fully characterize and monitor a site. The MWLID utilizes a systems approach that incorporates compatible and complementary technologies for site investigation.

One of the MWLID's primary goals is applying innovative technologies to minimize disturbance at landfills while maximizing information gathered by characterization methods. For source characterization, historical data and non-intrusive technologies that do not require holes to be drilled or samples to be taken are used to develop a sampling plan.

Non-intrusive methods include electromagnetic (EM) measurements and magnetometry. *Cross-borehole EM Imaging* can be used to map the subsurface of site by measuring the attenuation and phase shift of radio frequency signals propagated between boreholes. Since electrical properties, such as resistivity or electrical conductivity, are directly related to the chemical composition of the fluid passing through the geologic medium, contaminant source and plume detection may be possible. The *Magnetometer Towed Array* or *STHOLS* employs an array of seven magnetometers mounted on a buggy to rapidly survey a site. The vehicle and sensor platform have been designed to exhibit low magnetic signature to minimize interference with the magetometers. An on-board computer accepts magnetic data simultaneously with precise positioning data and outputs positions for every magnetic data point. Displayed on a video monitor, the magnet map of the surveyed area provides the user interface to semi-automated target analysis. A magnetic anomaly can be selected for a iterative least-squares model matching to determine the best fit of the magnetic moment and depth to the anomaly.

The ID is employing a *computerized sampling plan* using geostatistics that optimizes historical and non-intrusive field data to aid in the formulation of a sampling strategy. This sampling strategy provides guidance in sample placement for contaminant delineation. The plan assists in siting vertical and directionally-drilled boreholes and sampling locations along the boreholes.

New methods of directional drilling (drilling at an angle), and horizontal boring are being demonstrated to eliminate the problem of drilling-induced contaminant migration and contaminated drilling by-products. In addition, worker safety is enhanced because the drilling equipment can often be located at the periphery of the landfill. Two industry partners for these drilling projects are Charles Machine Works, (Oklahoma) and Water Development Corporation (California). *Measurement While Drilling (MWD)* is an innovative technology that is developing rapid, real-time gamma radiation screening capability during drilling.

New Mexico State University and Pacific Northwest Laboratory are partners in demonstrating a rapid field screening method, *stripping voltammetry* for the detection of heavy metals in soil samples retrieved through drilling. This method can analyze four metals simultaneously at parts-per-billion (ppb) levels within several hours of collection.

The *SEAMIST™* membrane liner, developed by Science Engineering Associates and demonstrated at the MWLID, is a promising technology that, for many applications, can replace the rigid casing found in most boreholes. *SEAMIST™* can be used for sample collection, in situ measurements, and transporting sensors downhole without allowing contact between the instruments and the contaminated soils. Sensors which operate downhole to detect contamination or measure soil properties reduce the number of soil samples which have to be obtained and sent offsite for analysis.

Many of the characterization technologies being evaluated are also compatible with long-term monitoring activities, and several will fulfill this dual role. A *Landfill Characterization and Monitoring System (LCMS)* is being developed that, in addition to stressing characterization activities, also emphasizes monitoring of the shallow vadose zone. Technologies that measure near-surface transport properties of fluids and gases in the vadose zone can provide valuable and necessary input to mandatory site-wide risk assessments.

Remediation

Site characterization provides the information necessary for the MWLID to tackle the technology development for remediation of mixed waste landfills using in-situ technologies that will minimize the risk from the landfill contents without excavating the waste materials and contaminated soils. This innovative remediation mission is based on the premises that (1) moving the landfill to another location only transfers the risk and (2) the national capacity for permitted mixed-waste is limited, thus encouraging management of mixed-waste landfills at their current location.

Few in-situ technologies are available to remediate contamination located in the area between the landfill and the groundwater. The vadose zone is an important area because it provides a barrier between the landfill and groundwater. While the vadose zone can effectively isolate and contain some contaminants, other contaminants may move quickly through this zone. When the vadose zone becomes contaminated with fast-moving pollutants, such as volatile organics, there is concern that pollutants may reach groundwater before intervention can take place. The MWLID focuses on safe, efficient, and effective new methods to remediate *fast-moving* contamination in the vadose zone and containment of the *slow-moving* contaminants to minimize their long-term migration. These remediation technologies can provide the basis for an advanced clean-up strategy.

The MWLID remediation technologies include extraction of fast moving VOCs and the transformation of heavy metal contaminants to nonmobile forms. Removal of the most rapidly moving constituents will then allow for long term remediation and/or containment and monitoring of the site.

Extraction. The MWLID is demonstrating an innovative extraction technologies. *Thermal Enhanced Vapor Extraction System* (TEVES) will demonstrate vacuum technology combined with soil heating methods and off-gas treatment to remediate volatile organic wastes that often are found at mixed waste landfills. Another extraction technology being developed is *electrokinetics* - a method where subsurface chromium contamination is moved through the soils by the application of a small electric field.

Transformation. Some soil contaminants, such as chromium, can exist in more than one redox state, with one more mobile than the other. Technologies are being evaluated to find ways to transform more mobile chromium to a less mobile state by a chemical reduction process. Technologies are also being evaluated to find ways to transform more mobile chromium to a less mobile state by a chemical reduction process.

Containment

Once the immediate threat of fast-moving contaminants is under control, the remaining landfill debris must be contained to minimize the long-term migration of slow-moving contaminants. Containment technologies involve: (1) the placement of surface covers to minimize precipitation infiltration into the landfill and leaching wastes into the surrounding soil; and (2) the placement of subsurface barriers to contain slow-moving soil contaminants.

Surface Covers. Above ground technologies, termed covers or caps, are required for the closure of all landfills in order to reduce the amount of water which leaches the waste out the landfill. Alternative cover designs which offer cost and technical advantages in arid and semi-arid regions are being demonstrated by the MWLID at Sandia National Laboratories and Los Alamos National Laboratory. The capillary barrier demonstrates the concept of the contrast in unsaturated hydraulic conductivity of a coarse layer (barrier) and an overlying finer layer limits the downward water flow. A dry barrier which utilizes air flow through course gravel layers in order to remove moisture from the cover system is also being evaluated. These cover designs are part of the *Advanced Landfill Cover Demonstration (ALCD)*, a side-by-side comparison of these designs with two RCRA caps and a soil cap. A computer-based decision tool for environmental restoration professionals for designing optimal cover designs is under development.

Subsurface Barriers. The ID is evaluating the feasibility of emplacement of *subsurface containment structures* to contain slow-moving soil contaminants. Using directionally drilled holes to gain access under a landfill, materials such as grouts can be emplaced to limit leachate movement from the site and can also provide a contained area for demonstration of transformation technologies. Optimal materials for these structures are being selected for evaluation. Other containment alternatives, such as permeable barriers which permit water flow but retain contaminants, are being evaluated. Methods to *verify* the subsurface barriers are meeting containment performance criteria are also being evaluated. Current verification techniques include geophysical, hydrological, and observational methods.

Technology Integration

Technology Integration is an integral part of the MWLID mission. The focus of the technology integration effort is to facilitate the involvement of outside participants in the ID activities, to expedite the transfer of the technologies to the private sector for commercialization and to hasten the adoption of successfully demonstrated technologies throughout the DOE complex and by other Federal agencies. The ID is working with federal, state, municipal, and tribal governmental agencies to expedite the regulatory approval and the use of these technologies. The MWLID is aggressively developing partnerships with the State, municipalities, tribal groups, and private industry to broaden the knowledge and use of its achievements. The ID is working with The New Mexico Environmental Alliance to apply innovative technical solutions to industrial environmental problems. The MWLID is an active participant in the DOE-sponsored Waste Management Education and Research Consortium (WERC), a research partnership among the New Mexico universities, national laboratories and the Navajo Community College. The ID provides internships and graduate research opportunities for students and educators to challenge them to become involved with innovative solutions to environmental problems.

Summary

Prior to May 1992, field demonstrations of characterization technologies were performed at an uncontaminated site near the Chemical Waste Landfill. In mid-1992 through summer 1993, both non-intrusive and intrusive characterization techniques were demonstrated at the Chemical Waste Landfill. Subsurface and dry barrier demonstration were started in summer 1993 and will continue into 1995. Future plans include demonstrations of innovative drilling, characterization and long-term monitoring, and remediation techniques. Demonstrations were also scheduled in summer 1993 at the Kirtland Air Force HSWA site and will continue in 1994.

The first phase of the TEVES project occurred in April 1992 when two holes were drilled and vapor extraction wells were installed at the Chemical Waste Landfill. Obtaining the engineering design and environmental permits necessary to implement this field demonstration will take until early 1994. Field demonstration of the vapor extraction system will occur during 1994.

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